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EFFECT OF DATE OF PLANTING ON CORN YIELDS, INSECT INFESTATION, AND FUNGOUS DISEASES

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INTRODUCTION

Insects and fungous diseases damage corn in Louisiana as much as in any other state and considerably more than they do in most of the corn growing states. This being true, the control of the diseases and insects is a matter of considerable importance. Poison dusts and sprays are not of practical value in the control; consequently some other measure must be sought. It has been known for some time that certain corn insects are more plentiful and do more damage to the growing corn at certain parts of the season than at others. The same information prevailed in regard to fungous diseases on corn. The study outlined in this bulletin was undertaken to determine as definitely as possible the relative insect and fungous disease infestation of corn in south Louisiana when planted at various dates of the period during which corn can be planted with satisfactory results. It was thought that this information would be of practical value to corn growers in that with it in hand, they might regulate, at no extra expense, their plantings to avoid peaks of infestation.

In south Louisiana the time during which corn may be planted for growing a crop ranges from about the middle of February to the middle of July. In parts of this region, the growing season is terminated largely by the prevalence of numerous insects and diseases. Where such conditions prevail, higher yields may be expected from the earlier plantings provided the stand and seedling vigor are not reduced too much by low temperatures and inadequate drainage. The rainfall throughout the corn growing season is usually adequate.

This study covers, for a five-year period, the corn yields secured from nine different dates of planting, ranging from the latter part of February to the first of July at approximately 15-day intervals, and the relative amount of disease affecting the plants of each planting date. The insects studied in detail were the southern corn root worm, frequently called corn bud worm, *Diabrotica duodecimpunctata* Fab.; cane borer, *Diatraea saccharalis* F.; corn ear

*Credit is due the Department of Entomology, Louisiana Agricultural Experiment Station, for aid in outlining this project, giving suggestions, and supplying insect photographs. The Department of Plant Pathology, Louisiana Agricultural Experiment Station, kindly furnished photographs of corn plants showing certain fungous diseases.

worm, *Heliothis obsoleta* Fab.; and the corn or rice weevil, *Sitophilus oryzae* L. The fungous diseases studied were the brown spot of corn, *Physoderma zeae-maydis* Shaw; smut, *Ustilago zeae* (Beckm.) Ung.; rust, *Puccinia sorghi* Schw.; and Diplodia dry rot, *Diplodia zeae* (Schw.) Leu. Other insects and fungous diseases were observed, but as they seemed to be of lesser importance, no detailed records were kept on their occurrence.

STUDIES MADE BY OTHER INVESTIGATORS

Experiments have been conducted in various regions to determine the best time for planting corn. Probably more of these tests have been conducted in the corn belt states than elsewhere. In this review, however, reference will be made only to the experiments that were carried on in southern states.

Mangelsdorf (1) concluded from experiments conducted in Texas from 1918 to 1927 that early-planted corn usually produces more than medium-early and practically always outyields late-planted corn, and that the loss in yield due to late planting varies with the season, the variety, and the locality. Time of planting and date of silking appear to be related, in that the period between planting and silking is shortened if the planting is delayed.

McClelland (2) found, from experiments conducted between 1917 and 1926 and involving a number of corn varieties, that April 15 is the best average planting date in northwest Arkansas.

Turner (3) states that the southern corn root worm injury to corn can be largely reduced or prevented in Alabama by planting after the first of May and planting a large number of kernels in each hill.

To prevent southern corn root worm injury, Thomas (4) recommends planting corn May 5 in southern South Carolina, May 12 in central South Carolina, and May 19 in the Piedmont Region.

Luginhill (5) states that to prevent serious injury to corn by the southern corn root worm, lowlands in southern Georgia and western Florida should not be planted before April 20 to May 1; and in central Georgia and the southern half of South Carolina, not before May 1 to May 10.

Arant (6 and 7) of Alabama made a study of the biology and control of the southern corn root worm. He found that there was frequently a heavy infestation of root worms on corn following the turning of winter legumes and that the optimum date for corn planting varied with the date of turning under the legumes. If the legumes were plowed under on March 15, corn planted three weeks after that date became heavily infested, but if turned on April 1, corn planted in three weeks after that date was not bothered seriously; and when legumes were turned under April 15, there was no bad injury to corn planted two weeks after that date.

In Bradley's (8) experiments at Baton Rouge, in 1924, the southern corn root worm caused no injury to plantings made prior to March 31. Six per cent of the plants of this planting were killed, 38.6 per cent in the planting made on April 8, and 16 per cent in the April 14 planting. The plantings made April 21 and April 29 had 3.9 and 1.7 per cent, respectively, of the plants infested. The root worms caused no damage in plantings made after April 29. The corn ear worm infestation was high and fairly constant in all the plantings except that of May 8, when it dropped to 58.6 per cent.

Phillips and Barber (9), in their study of the corn ear worm in West Virginia, found the average number of kernels destroyed per ear and also the reduction in yield of grain to be least in the earliest planted plots and fields and greatest in those planted on the latest dates.

LOUISIANA EXPERIMENTS

Soil and Climatic Conditions

The experiments were conducted on a Sharkey soil of the Mississippi river bottom at Baton Rouge. The soil and climatic conditions are similar to those in a large part of south Louisiana. The soil is rather fertile and crops usually grow rank when properly cultivated. A complete fertilizer was applied to the seedbed of all the plots in 1933 and in 1937 at the rate of 550 and 300 pounds per acre, respectively. Nitrate of soda was applied as a side-dressing in 1933 and in 1934 at the rate of 200 and 150 pounds per acre, respectively.

Corn seldom suffers from lack of moisture in the vicinity of Baton Rouge. The annual rainfall usually ranges between 55 and 60 inches. It is rather evenly distributed throughout the year. Table 1 gives the weekly rainfall records for the major part of the growing season during the years of 1933 to 1937, inclusive. The data show that only one three-week period occurred without rain during the growing season and 2.87 inches fell the next week. During these same years, only four two-week and only ten one-week periods occurred without rain.

Methods Used

Nine plantings were made each year at approximately fifteen-day intervals beginning as near February 25 as the weather would permit and ending about July 3. Five-row plots with rows 110 feet long and 4 feet wide were used throughout the experiment. Four replications were planted on each of the nine dates.

The corn was planted with Otootan soybeans in alternate hills in the same row, a duplex hopper being used. The hills were 26 inches apart, with four to seven kernels in each. When the plants reached 8 to 10 inches in height, they were thinned to two stalks per hill. In 1936 and 1937, Creco, a Cocke's Prolific x Yellow Creole

hybrid corn, was planted. Yellow Creole was planted the three previous years. The soil preparation, planting and cultivation were the same for each date of planting.

Beginning at the seedling stage, weekly observations were made on each plot until the plants reached maturity. The fifth row of each plot was used during the growing season for the disease and insect studies. The plants were counted before and after thinning and the number infested with various diseases and insects recorded from week to week in order to determine the percentage affected in the different dates of planting.

The three middle rows were harvested for yield calculations. The ears on the middle row were snapped with the husk. At the end of the row the husk was removed over white pans and a record made of the ears infested with weevils, cane borers, smut, and Diplodia ear rot. The number of weevils per ear was also recorded.

TABLE 1. WEEKLY PRECIPITATION AT BATON ROUGE DURING CERTAIN MONTHS OF THE YEAR, 1933-1937, INCLUSIVE

		YEAR				
		1933	1934	1935	1936	1937
March	1- 7	2.26	1.42	1.58	.12	.67
	8-14	1.24	.58	1.96	.65	.15
	15-21	.87	.22	.17	.26	1.14
	22-28	.66	.77	...	.28	1.24
	29-31	.03	...	1.43	...	.58
April	1- 7	2.62	.77	1.90	.07	2.07
	8-14	1.35	1.26	.07	2.51	.03
	15-21	2.86	2.77	3.23	...	...
	22-28	1.09	.08	3.64	...	.86
	29-30	...	.58	.09	1.22	.01
May	1- 7	1.29	.86	1.13	*	3.38
	8-14	...	1.15	...	*	.16
	15-21	...	1.56	3.21	*	...
	22-28	2.35	1.70	...	*	...
	29-31	.79	...	...	*	...
June	1- 7	...	3.05	1.59	...	2.87
	8-14	.83	.21	.23	...	.84
	15-21	.97	4.03	2.55	.05	.11
	22-28	2.03	.16	.10	.01	.04
	29-30	...	1.58	.10	...	...
July	1- 7	.97	3.06	2.89	.78	.03
	8-14	.53	.14	2.32	2.28	1.65
	15-21	2.57	1.49	.23	.07	.87
	22-28	2.06	2.94	3.83	2.72	.05
	29-31	.24	2.39	...	.78	1.49
Aug.	1- 7	2.03	1.08	.68	.45	.60
	8-14	1.45	1.12	.462	.83	.17
	15-21	.84	.26	.25	.33	2.47
	22-28	.04	1.93	1.88	2.80	1.49
	29-31	1.36	1.48	.01	1.33	1.97

*Data unavailable.

Results from Studies Made

As was mentioned previously, four insect species and four fungi most harmful to corn growing in south Louisiana were studied. The southern corn root worm, or corn bud worm as it is often called, will be briefly discussed first.

SOUTHERN CORN ROOT WORM

The southern corn root worm, *Diabrotica duodecimpunctata* Fab., is found practically everywhere in the United States east of the Rocky Mountains, in southern Canada, and in Mexico, but it is a more serious pest to the corn in the Southeastern and Gulf Coast states.

The adult stage of the southern corn root worm is a small beetle (*a* in Fig. 1) about one-fourth of an inch long, yellowish-green with black legs and head and twelve black spots on its back. It feeds on the pollen of almost every growing plant and the tender stems and leaves of cucumber, squash, winter peas, vetch, young corn plants, and many other plants. It is often called the twelve-spotted cucumber beetle on account of its habit of feeding on cucumber plants. The insect passes the winter in the adult stage, usually inactive, but in south Louisiana, and in the southern parts of other Gulf States, where the temperature is well above freezing the greater part of the winter, the adult can be seen flying from place to place feeding on the tender leaves and stems of winter peas, vetch, and other vegetation during the warm days of January, February, and March.

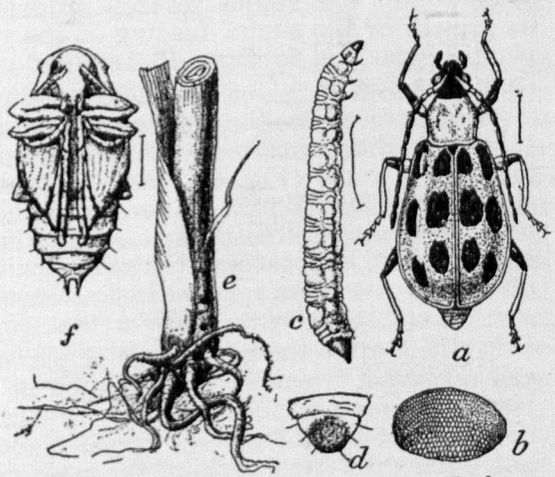


FIG. 1.—Southern corn root worm *(Diabrotica 12-punctata)*: *a*, beetle; *b*, egg; *c*, larva; *d*, anal segment of larva; *e*, work of larva at base of cornstalks; *f*, pupa—all much enlarged except *e*, which is reduced (reengraved after Riley, except *f*, after Chittenden.—*(U. S. Bureau of Entomology.)*

The eggs are deposited at random in the soil, just below the surface. Various investigators report that each female living over winter is capable of laying 75 to 100 eggs. In the vicinity of Baton Rouge, the females living over winter lay the greater portion of their eggs during February and early March. The eggs (Fig. 1) are oval in shape and about the size of a pin head. During the early spring they usually hatch in three to four weeks. At

the end of the incubation period a very small slender-shaped larva gnaws through the covering of the egg (shell) and begins independent existence. The grown larva is about one-half inch long and tapers toward the head end. It is yellowish-white in color and has a dark brown head and a dark patch on the top of the last body segment. When the larva reaches maturity, it enters the ground to a depth of a few inches, and encloses itself in a cell to go into the pupal, or resting, stage (Fig. 1). It remains in this stage about two weeks during the spring, but in the summer, one week is usually sufficient. At the end of this period the adult emerges from the pupa and makes its way to the surface of the ground. The number of generations per year varies in different parts of the country. There are two generations annually at Columbia, South Carolina, three annually at Auburn, Alabama, and in the vicinity of Baton Rouge, four generations usually develop each year.

The adult beetle, while less destructive than the larva, may cause injury to the foliage of the young corn plants during certain periods of the year. The second generation and possibly some of the third emerge by the last of June and the first of July and the number of adults is perhaps greater at this time than at any other period of the year. During some years corn planted after June 15 is rather severely injured the first two weeks of its growth by the adults' feeding on the young tender leaves. Corn planted previous to June 15 receives very little, if any, injury from this source.

The larva causes the most severe damage to young corn plants. It may feed upon the roots or bore into the stem just above the top ring of roots (Fig. 1). In the former case, the plants become stunted and leaves turn yellow, but plants may recover later and produce grain. In the latter case, the larva drills inside the base of the plant and causes the bud to wither and die. The entire plant may die when injured badly. Injured plants, however, may survive, giving rise to suckers that produce little or no grain.

Table 2 gives the percentage of plants infested with the southern corn root worm in corn planted at various dates during the planting season of four successive years. From this table it may be seen that the infestation varied a good deal from year to year and during different parts of the same year. In general, the infestation was much heavier on corn planted during February and March than on corn planted during April and May. There is a slight increase in the infestation in corn planted the middle of June. This increase is probably due to the large number of adult insects present at this time and the scarcity of tender young plants on which to feed.

The growth of green vegetation on the plots during the winter and early spring seems to be largely responsible for the wide variation in root worm infestation in different years. In the winter and early spring of 1934, the plot seedbeds were covered with

TABLE 2. PERCENTAGE OF CORN PLANTS INFESTED WITH THE SOUTHERN CORN ROOT WORM

Year	DATE OF PLANTING								
	Feb. 25	Mar. 12	Mar. 28	Apr. 12	Apr. 28	May 15	June 1	June 15	July 3
1934	44.1	56.1	65.1	3.8	1.1	2.1	1.5	4.7	3.5
1935	14.9	20.3	19.7	1.8	.0	.0	.7	.7	4.4
1936	8.4	28.8	17.0	.7	.3	.0	.0	.0	.3
1937	2.7	4.6	4.4	1.7	.0	.0	.0	3.4	.6
Average	17.5	27.5	26.6	2.0	.4	.5	.5	2.2	2.2

a heavy growth of chick weeds, which attracted many adults on the warm days of January and February. These adults deposited a large number of eggs in the soil. Eggs continued to hatch several days after the seedbeds were prepared for planting, and the larvae remained in the soil until the young corn seedlings began growth. The growth of chick weeds was less in the winters of 1935 and 1936. The seedbeds were free of vegetation in the winter of 1937 and the root worm infestation failed to exceed 4.6 per cent during the season. It seems, therefore, that corn is more likely to be damaged by the southern corn root worm when planted where green vegetation has grown during the winter and early spring, unless the seedbeds are allowed to remain bare for a period of several weeks before planting.

Corn following legume or other winter cover crops is apt to be damaged worse than other corn by the southern corn root worm and by other insects, but the trouble can be lessened greatly if the corn planting is delayed three weeks or more after the cover crop is turned under.

In regions where corn is susceptible to root worm injury, it is very desirable to plant two or three times the quantity of seed otherwise necessary to secure a stand. When the plants become 5 to 8 inches tall they may be thinned to the desired stand and the injured plants removed. After the plants reach this stage of growth, the buds are not injured by the root worms. In these studies a heavy rate of seeding was used and the highest infestation did not destroy the stand.

The southern corn root worm causes the most damage to corn planted on low, wet ground. Under these conditions the plants grow slowly and remain longer in the stage susceptible to root worm injury. Such areas, if planted in corn, should be properly drained and the corn planted on a well-prepared seedbed during the middle or latter part of April.

CORN EAR WORM

The corn ear worm, *Heliothis obsoleta* Fab., is the larva of a moth (Fig. 2) that has been a destructive insect pest of ear corn for many years. It occurs throughout the United States wherever this crop is grown. It is most abundant, however, and most

destructive in the Southern States, where its breeding season is longer and where many of its secondary host plants are grown. Although corn is its favorite food, this insect also infests tomato fruits, cotton bolls, and tobacco seed pods. It is known to tomato growers as the "tomato fruit worm." As a pest to cotton, it is called the "bollworm," and is known by tobacco growers as the "tobacco worm."

During the corn ear worm's lifetime, it passes through four distinct stages: the egg, the larva or worm, the pupa, and the moth or adult.

The egg (Fig. 2) is approximately half the size of the head of a common pin and its shape is similar to a ball flattened on opposite sides. Its color is light at first, but as hatching time approaches, it changes to a dull brown. The eggs usually hatch in from 2 to 7 days, depending on the temperature.

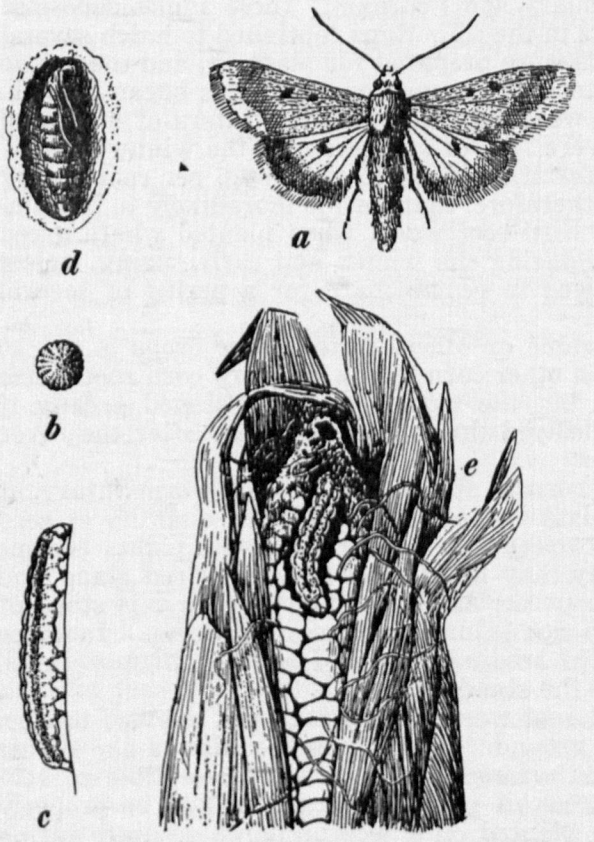


FIG. 2—Corn ear worm: *a*, moth; *b*, egg enlarged; *c*, larva; *d*, pupa in earthen cell; *e*, larva feeding on corn ear. (After Haseman.)

The larva is whitish in color, with a black head, and is very small when it first appears. Growth however is very rapid, and the larva attains full size in from 13 to 28 days. When full-grown, it is about one and one-half inches long and very robust. Its color and size vary greatly.

At maturity, the larva leaves the ear, usually by boring out through the husk, and drops to the ground. It enters the soil to a depth of from 1 to 9 inches, depending on the moisture, type of soil, and weather conditions. The larva then forms a cell at this depth in which to pupate. The pupa (Fig. 2) is completely inactive. The length of the pupal period is determined by the season of the year. During the summer it may

be as short as 12 to 17 days. Larvae entering the ground during the fall may remain in the pupal stage for several months, as it is in this stage that the insect passes the winter.

The corn ear worm is subject to many hazards when in the pupal stage, some of which are moles, unfavorable weather conditions, disease, and destruction of the channels to the surface during seedbed preparation and crop cultivation. It has been estimated that not over 5 or 6 per cent of the larvae which enter the soil in the fall survive to emerge as moths the following spring.

From the pupa emerges the adult moth, which is about three-fourths of an inch long and has a wing spread of about one and one-half inches (Fig. 2). Its color varies from a light olive green to a rather dark reddish-brown. The moth is very inconspicuous and is seldom seen by the farmer. It is most often seen, however, during midday resting on the central shoot, or "bud-leaves," of the corn plant. The moth becomes very active in the early evening, feeds on the nectar of various flowers, and flies in search of suitable plants on which to deposit eggs. The female lives about 12 days and during this period deposits on the average about 1,000 eggs. These are usually laid singly on a large number of plants, but several may be deposited on different parts of an individual plant. A few eggs are deposited on the leaves of the young corn plants, but the moth prefers fresh silks on which to deposit her eggs, and when the silks appear, very few eggs are deposited elsewhere.

Under the most favorable conditions, the life cycle of the corn ear worm may be as short as 30 days. In the Southern States, generations develop very rapidly and as many as five to seven may develop during one breeding season. There is only one generation annually in the more northerly portions of the United States and in Canada.

The damage by the corn ear worm insect is all done by the larva. It eats young leaves, tassels, and silks, and the tender kernels of the ear, the worst damage being done to the ear. The buds, or central shoots, of late planted corn are usually more heavily infested than are those of early plantings. At Baton Rouge, ear worms frequently feed on 20 to 50 per cent of the plants in the late June and July plantings, many of the plants being so badly mutilated that they never recover. This type of injury is much less on the earlier plantings.

As may be seen from Table 3, many plants from all dates of planting were infested with corn ear worms. There were no decided peaks during any part of the season, but it appears that the March and April 12 plantings were infested somewhat less than plantings made on other dates.

CANE BORER

The cane borer is the larva of a moth common in sugarcane fields, especially late in the summer (Fig. 3). The cane borer, *Diatraea saccharalis* F., has been recognized in south Louisiana for

TABLE 3. THE PERCENTAGE OF PLANTS WITH EARS INFESTED WITH CORN EAR WORMS

Year	DATE OF PLANTING								
	Feb. 25	Mar. 12	Mar. 28	Apr. 12	Apr. 28	May 15	June 1	June 15	July 3
1934	...	...	...	48.0	86.0	80.0	90.0	94.0	99.0
1935	82.0	66.3	59.4	83.7	93.2	91.6	90.7	83.5	64.8*
1936	73.0	43.2	23.4	61.1	90.9	85.7	86.2	84.1	79.4*
1937	55.5	46.4	38.2	33.8	73.1	91.7	81.8	81.2	55.2
Average	70.2	51.9	40.3	56.7	85.8	87.3	87.2	85.7	74.6*

*The percentage of barren plants included as ear-worm-free is higher than in the earlier plantings.

50 years or more as a serious pest of corn and sugarcane. The increased damage caused by the borer during the last years of the past century caused the Louisiana Experiment Station to begin a study of the insect. This work was started by Morgan (10) about 1900. In his studies, he observed that the adult moth lays eggs in small clusters on the surface of leaves on the upper part of corn plants. The eggs hatch in 5 to 10 days, depending on the temperature prevailing. The larva or young borer is very small when it emerges from the egg—so small, in fact, that it will not be seen unless a careful search is made. The young borer moves along the surface of the leaf to the cluster of leaves forming the terminal bud of the plant. It burrows into this roll of leaves in such a way that when the leaf unfolds it commonly shows a row of round holes extending laterally across the leaf. The corn ear worm also perforates corn leaves, but the holes made by the ear worm are more irregular as to size and position, not forming regular lines of holes across the leaf.

As the borers approach maturity, they tunnel downward into the stalk proper, feeding there and making prominent tunnels. In some stalks these tunnels may be so numerous and large that the stalks are weakened and they tend to break and fall late in the summer. The existence of the borer in the corn may be easily detected by the presence of rather prominent exit holes along the central or lower part of the stalk. Larvae developing during July reach maturity in 25 to 28 days, but those developing late in the season may remain in the stalk and not pupate until March or April the following spring. The pupa also spends its entire life period within the corn stalk, the length of time varying with the temperature and ranging from 7 to 27 days.

From the pupa emerges the adult moth (Fig. 3). It escapes from the corn stalk through one of the characteristic borer holes that the larva made before it entered the pupal stage. The moth commonly emerges at night, and after expanding its wings, it usually hangs to some plants or other object during the entire following day. During the second night mating takes place and

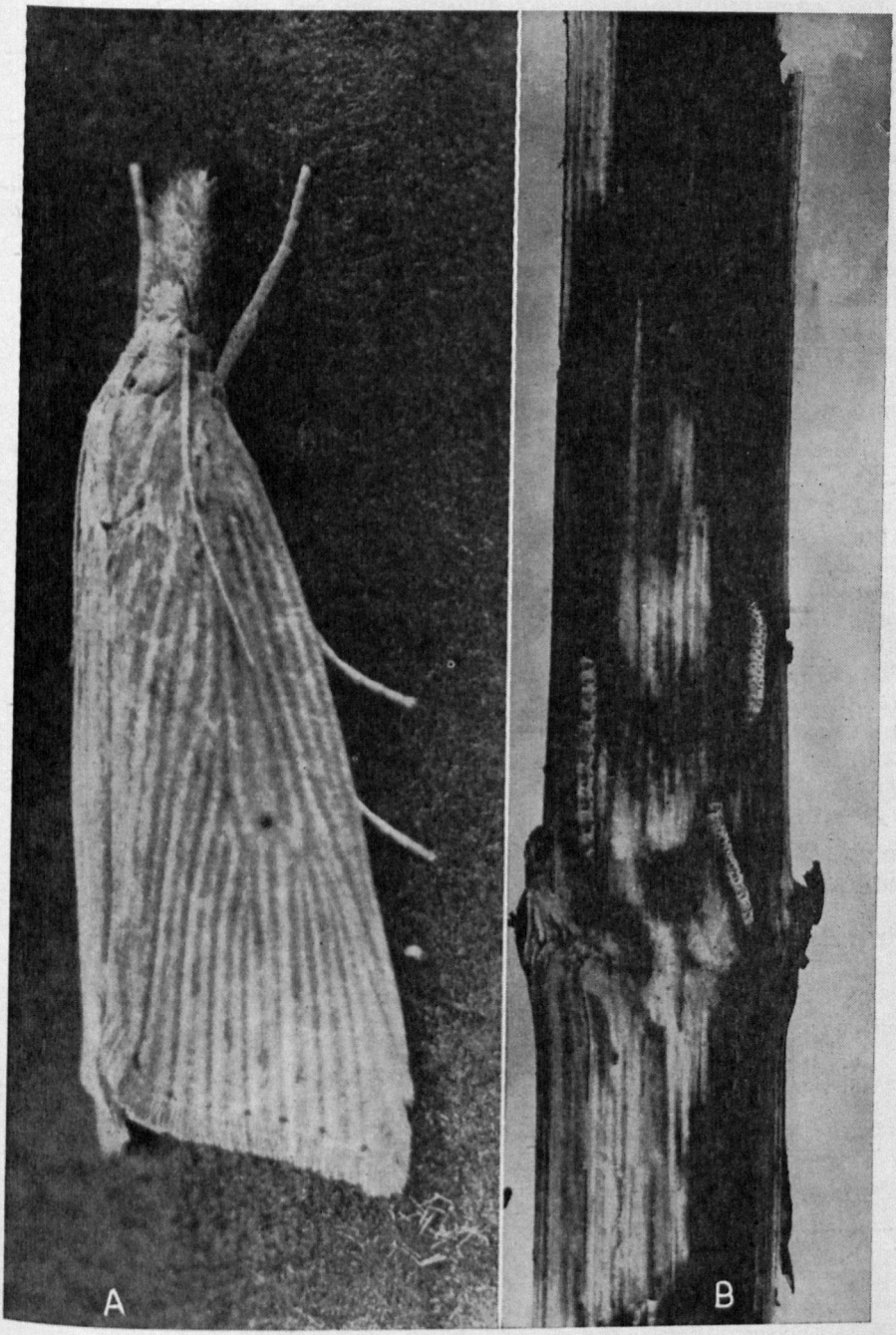


FIG. 3.—Cane borer: *a*, moth, much enlarged; *b*, cornstalk showing borer larvae and tunnels made in the stalk.

a few eggs may be deposited, but the bulk of the eggs are deposited the following three or four nights. Moths are most active in the late evening and seldom take flight during the day. The duration of a moth's life usually ranges between 2 and 10 days.

Borer damage may be worse if corn and cane are grown in adjacent fields since the two will provide more satisfactory host plants. Morgan (10) states: "Corn is more succulent, more rapid in development, and thus in the economy of the borer assures the development of many more specimens than if cane were the only food plant. From the first appearance of young cane shoots up to June the 1st or 15th, but few borers can be found on individual plants (not more than five or six, commonly only two or three), while upon corn at this season as many as fifty-six have been found upon a single stalk, while from fifteen to thirty to the stalk is of usual occurrence."

The percentage of plants infested with cane borers for various dates of planting is shown in Table 4. The average percentage of plants infested with borers ranged from 55.9 to 59.0 in the February, March, and April 12 plantings. In later plantings, the average percentage ranged from 71.0 in the April 28 to 99.1 in the July 3 planting. There was an average of 8.24 per cent increase in infestation for each delay of 15 days in plantings made after April 12. The later plantings suffered greater injury than the earlier ones because there was a higher percentage of infestation and more borers in a plant. These succulent, rapid growing plants were apparently more desirable host plants. The vitality and production of the plants is lowered if they contain borers, and they are apt to break down.

Table 5 gives the percentage of infested ears for various dates of planting. A close relation is shown between the date of planting and the infestation of the ears. With each delay of 15 days in planting from February 25 to July 3, the percentage of infested ears increased 4.24 per cent, the range being from 10.9 to 44.8 per cent.

TABLE 4. PERCENTAGE OF PLANTS AT BATON ROUGE INFESTED WITH THE CANE BORER

Year	DATE OF PLANTING								
	Feb. 25	Mar. 12	Mar. 28	Apr. 12	Apr. 28	May 15	June 1	June 15	July 3
1933	...	...	...	...	54.0	61.0	82.5	100.0	100.0
1934	85.0	94.0	97.0	97.4	99.0	100.0	100.0	100.0	98.7
1935	30.6	39.5	32.8	29.3	61.2	68.1	73.9	73.4	97.0
1936	25.9	22.9	21.7	29.3	55.4	74.0	81.2	84.4	100.0
1937	82.2	71.7	84.6	75.8	85.4	96.5	93.1	96.3	100.0
Average	55.9	57.0	59.0	57.9	71.0	79.9	86.1	90.8	99.1

TABLE 5. PERCENTAGE OF EARS INFESTED WITH THE CANE BORER

Year	DATE OF PLANTING								
	Feb. 25	Mar. 12	Mar. 28	Apr. 12	Apr. 28	May 15	June 1	June 15	July 3
1933	...	...	...	8.2	9.3	6.8	8.9	11.6	23.3
1934	21.5	29.4	36.1	38.6	35.0	48.3	46.3	46.9	43.8
1935	6.5	3.3	6.3	10.9	8.4	11.9	11.3	19.7	...
1936	2.8	2.8	3.4	5.4	8.5	13.4	13.3	57.8	68.7
1937	12.9	14.1	13.1	14.9	24.1	22.6	25.2	35.4	43.2
Average	10.9	12.4	14.7	15.6	17.1	20.6	21.0	34.4	44.8

RICE, OR "GRAIN," WEEVIL

The rice weevil, *Sitophilus oryzae* Linn., is commonly known to corn growers as the corn or black weevil. India is thought to be its original home. It occurs throughout the grain-growing regions of the United States and in the Southern States is the most serious pest to stored grain. In some of the Gulf Coast states, the corn weevil damages much corn in the fields before harvest.

The weevil passes through four distinct stages during its life time: the adult, the larva, the pupa, and the egg.

The adult weevil (Fig. 4) is about one-sixth of an inch long, including the snout. A pair of antennae is located on the snout. The color of the adult varies from a light brown to dusty black. The thorax is covered with a network of very small round punctures, and small punctures arranged in longitudinal rows are present on the first pair of wings. The first pair of wings serves to protect the second, which are membraneous in character and are used for flying. The adult usually lives four to five months. It is estimated that one pair will, in the course of a year, produce over 6,000 descendants.

The egg is very small and has a whitish appearance. It is deposited in punctures made in the grain by the adult.

The larva is about one-eighth to one-sixth inch long at maturity, whitish in appearance, and rather robust. During the larval stage, the insect gnaws toward the center of the kernel, leaving an open channel through which the adult may escape. When maturity is reached, the larva transforms into the pupal, or resting, stage, from which emerges the adult.

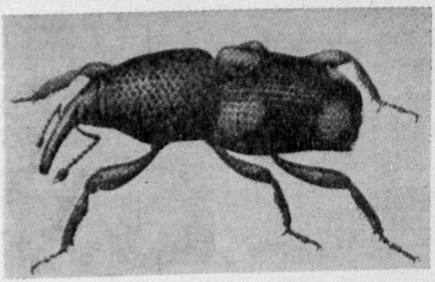


FIG. 4.—Rice, or grain, weevil, several times natural size. (After Girault.)

A large number of generations develop annually in the southern portion of the United States. With favorable conditions, the weevil passes through its four stages of development in four to six weeks.

The adult feeds for many weeks within the kernels, rendering them unfit for human consumption and reducing their value considerably as food for livestock. When weevil infestation is heavy, the entire inner portion of the kernel may be destroyed.

The weevils fly from infested stored grain into fields and attack the ripening grain. However, the stored grain may be protected and field infestation reduced materially by fumigating the stored grain with carbon bisulphide.

The percentage of ears infested with weevils when harvested and number of weevils per infested ear for different dates of planting are shown in Table 6. The corn from the first seven plantings was harvested during the last week of September and first two weeks of October. The rest was harvested some six weeks later because it was not ripe enough for harvest when the other corn was gathered. Judging from data in this table, it appears that the early and late planted corn are somewhat more subject to weevil attack than corn planted the latter part of April and in May. The earlier corn was probably worse infested due to the fact that the mature ears were hanging on the stalks some weeks before being gathered. This gave the weevils more chance to collect in them and reproduce there. The June 15 and July 3 plantings were harvested some weeks after the other plantings had been harvested. This gave weevils from early harvested plots a chance to migrate to and collect in the ears of the late plantings. Under uniform field conditions, there probably is not much difference in weevil infestation resulting from planting at different times.

PHYSODERMA, OR "BROWN SPOT," DISEASE OF CORN

Agronomists and pathologists at various southern experiment stations estimate that Physoderma causes an annual loss of 5 to 10 per cent of the corn crop in some sections of the South. This disease, which is caused by the fungus *Physoderma zeae-maydis* Shaw, manifests itself by yellowish or reddish-brown spots and streaks on leaves, leaf sheaths, stalks, and occasionally the outer husks of ears of the corn plant (Fig. 5).

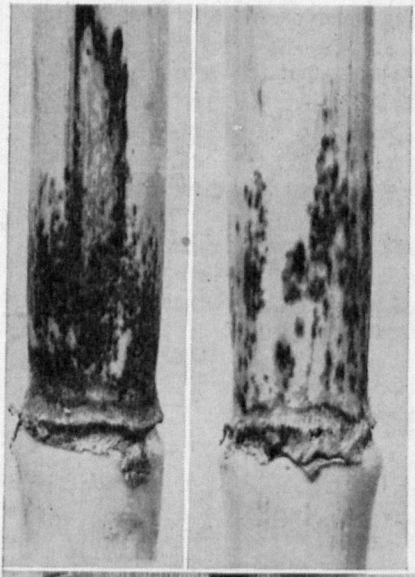
Tisdale (11) has given a comprehensive discussion of the history, distribution, economic importance, and possible control measures of Physoderma and the life cycle of the causal organism. He found that the sporangia of this fungus live over the winter on diseased corn plants of the previous crop and in the soil. They germinate the following summer, producing numerous spores. The spores are disseminated by the wind principally and lodge on growing plants. They germinate there under proper conditions of temperature and moisture and produce a large number of smaller swimming spores which swim in the water held in the bud and leaf sheaths. They finally come to rest on the tissue of the plant where they then germinate and the fungus penetrates the cells of the plant.

TABLE 6. PERCENTAGE OF EARS INFESTED WITH RICE "GRAIN" WEEVILS AND NUMBER OF WEEVILS PER INFESTED EAR IN DIFFERENT DATES OF PLANTING

Date of Planting	1934		1935		1936		1937		Average	
	Per cent infested ears	Number weevils per infested ear	Per cent infested ears	Number weevils per infested ear	Per cent infested ears	Number weevils per infested ear	Per cent infested ears	Number weevils per infested ear	Per cent infested ears	Number weevils per infested ear
February 25	11.6	6.3	22.6	10.1	24.9	7.9	54.9	15.7	28.5	10.0
March 12	8.8	2.5	9.9	6.9	16.0	5.9	48.5	8.5	20.8	6.0
March 28	8.6	2.9	5.6	5.5	14.9	4.5	29.1	4.9	14.6	4.5
April 12	8.9	3.7	4.2	4.5	16.9	4.6	24.1	4.6	13.5	4.4
April 28	21.4	5.7	1.6	2.9	8.3	2.8	7.8	1.6	9.8	3.3
May 15	12.0	2.9	2.6	2.8	4.2	2.7	2.4	2.8	5.3	2.8
June 1	12.4	3.3	4.3	2.1	3.9	2.7	1.6	1.3	5.5	2.4
June 15	24.7	2.7	15.4	3.9	22.9	3.6	13.8	2.8	19.2	3.3
July 3	39.8	4.6			57.2	8.4	25.2	2.9	40.7	4.0

If the Physoderma infection in a field of corn is heavy, there is enough of the fungus organism growing within the tissues of the leaf to destroy cells and interfere with photosynthesis. This naturally weakens the plant and reduces its production. In some cases, too, where the infection is heavy, the organism passes from the leaf sheath into the stem near the joints. The tissues of the stem at that point are so weakened and destroyed that the stem may break when there is a wind, causing the plant to lodge.

The data given in Table 7 show how the date of planting influences age of plants when infected under field conditions. With each delay of 15 days in planting from February 25 to June 1, inclusive, the plants are approximately seven days younger when infected. The disease made its first appearance the last part of May and the first of June on corn planted in February, March, and April. The maximum infection is usually reached by the middle of June in plantings made during February and March. The maximum infection in the April plantings usually occurred the first week in July. Plantings made May 15 reached maximum infection July 18; June 15, reached maximum infection August 4; and July 3, reached maximum infection August 17.



From a study of Table 8, which gives the amount of Physoderma infection following each date of planting for a four-year period, it appears that up to May 15, there is no significant difference from

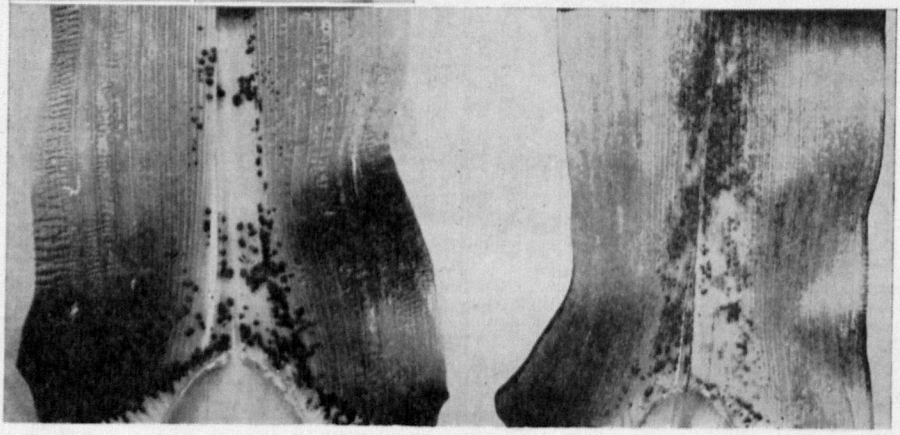


FIG. 5.—Physoderma on corn.

TABLE 7. RELATION OF THE DATE OF PLANTING TO THE DATE OF FIRST AND LAST INFECTION AND AGE OF PLANTS WHEN INFECTED WITH *Physoderma zeae-maydis*

Date of planting	Date of first infection	Date of last infection	Age of plants when first infected	Age of plants when last infected
February 25	May 20	June 11	85 days	107 days
March 12	May 22	June 15	71 days	95 days
March 28	May 25	June 17	58 days	81 days
April 12	May 31	July 1	49 days	79 days
April 28	June 15	July 8	48 days	71 days
May 15	June 25	July 18	41 days	63 days
June 1	July 6	July 23	35 days	53 days
June 15	July 27	Aug. 4	41 days	49 days
July 3	Aug. 10	Aug. 17	31 days	45 days

the different dates. Plantings made in June and July had less infection. The higher temperatures prevailing during the summer months probably destroyed more of the Physoderma spores and made inoculation less effective. Table 8 shows, however, that there is a significant increase in the amount of infection in successive years. This may be explained by the fact that the same land was in corn for five successive years. Many spores were carried over from year to year on old corn stalks. This suggests that crop rotation will be helpful as a control measure.

TABLE 8. PERCENTAGE OF CORN PLANTS INFECTED WITH *Physoderma zeae-maydis*

	DATE OF PLANTING								
Year	Feb. 25	Mar. 12	Mar. 28	Apr. 12	Apr. 28	May 15	June 1	June 15	July 3
1934	3.6	2.5	1.6	12.5	11.1	46.9	9.5	1.3	0.9
1935	13.5	10.1	8.3	22.3	31.7	22.5	20.8	0.8	1.8
1936	25.4	29.4	27.7	29.8	8.1	6.5	3.1	0.3	.0
1937	46.8	44.2	50.6	17.0	19.7	33.9	2.0	8.6	4.9
Average	22.3	21.6	22.1	20.4	17.7	27.5	8.9	2.8	1.9

DIPLODIA DRY ROT

Of the several fungous diseases that attack the corn ear, Diplodia dry rot (Fig. 6) is probably the worst. It occurs in all the corn-growing regions of the United States but causes the greatest injury in the southern and southeastern states.

The fungi that cause Diplodia dry rot, *Diplodia zeae* (Schw.) Leu., and *Diplodia macrospora* Earle, live over winter as dormant mycelium in the corn seed and in the rotten ears, husks, and stalks of the previous crop. Spores are formed in the spring and carried by the wind to growing plants. They lodge about the tip of the

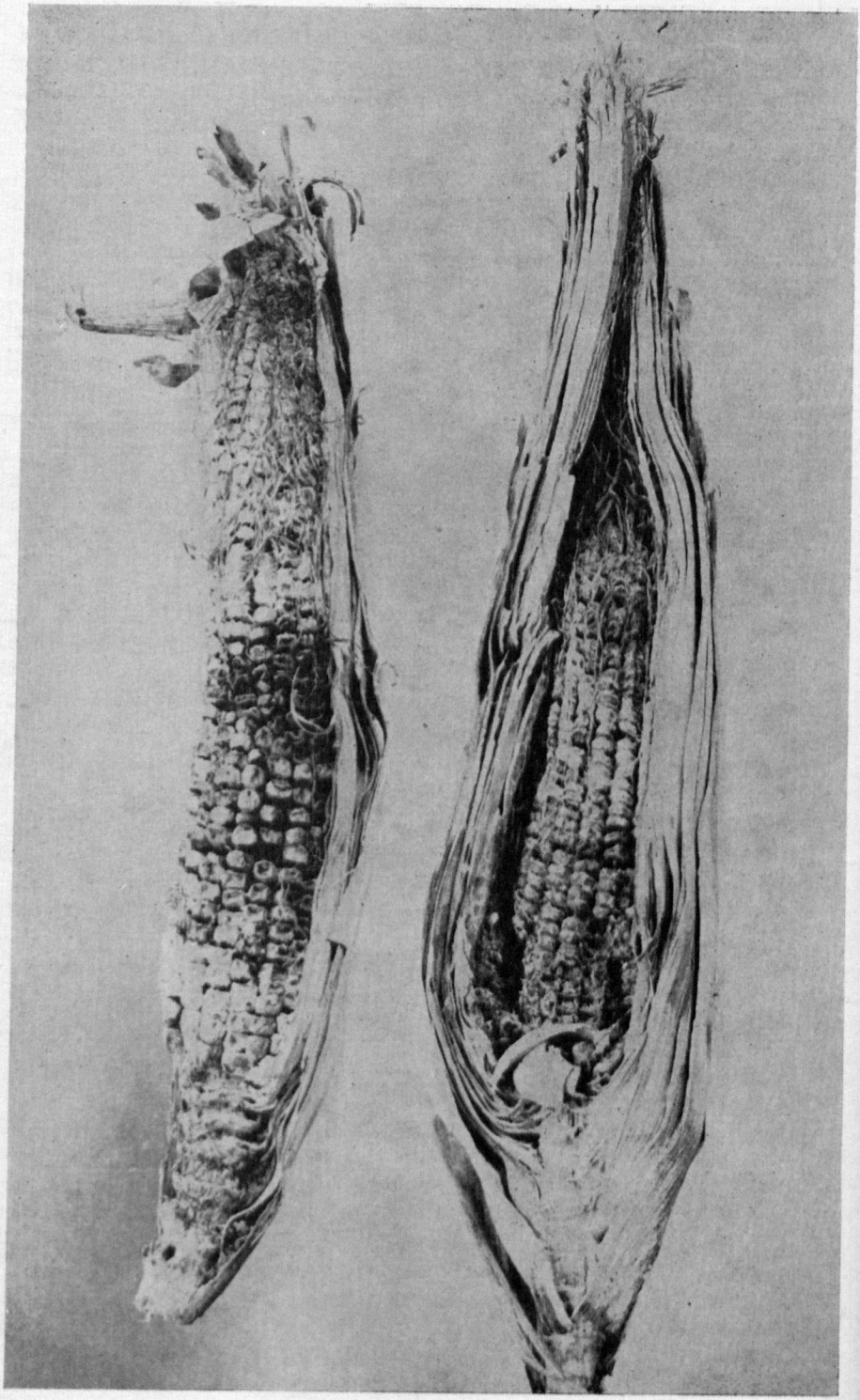


FIG. 6—Ears showing effect of Diplodia ear rot.

ear or at its base and germinate when favorable conditions arrive, thus infecting the ear. The entire ear may become diseased, or only the tip or butt. An infected ear may be recognized before it reaches maturity by the pale yellowish-green color of the husk. The diseased ears when mature show grayish-white to brownish kernels loosely attached to the cob.

The percentage of diseased ears from the different planting dates is shown in Table 9. It will be noted that while there are no great differences for the various dates, there is a gradual increase in infection as the season progresses, the infection being two or three times as great in June and July plantings as in those of February and March. Crop rotation and early planting are control measures.

TABLE 9. PERCENTAGE OF EARS INFECTED WITH DIPLODIA DRY ROT

Year	DATE OF PLANTING								
	Feb. 25	Mar. 12	Mar. 28	Apr. 12	Apr. 28	May 15	June 1	June 15	July 3
1933	...	...	...	...	.5	.2	.0	1.3	.0
1934	.0	.0	.0	7.7	7.4	4.8	5.2	4.6	2.0
1935	3.9	3.3	4.7	4.6	4.4	3.5	7.3	10.0	...
1936	1.1	1.5	4.2	6.2	8.0	7.4	12.8	8.4	3.1
1937	11.4	8.6	6.4	6.5	11.0	16.1	30.8	29.1	33.3
Average	4.1	3.4	3.8	6.3	6.3	6.4	14.1	10.7	9.6

CORN SMUT

The common smut of corn is caused by the fungus organism known as *Ustilago zeae* (Beckm.) Ung. Infection of smut may appear on all aerial parts of the corn plant: tassels, ears, stems, leaves, and occasionally on the brace roots. Figure 7 shows an ear and leaves infected with the disease.

Smut spores live over winter in the soil rather than on the seed. Occasionally they may be found in manure. During the spring the spores are carried by the wind from the soil to the growing plants where they lodge, germinate, and with proper moisture and temperature conditions, produce hyphae that penetrate the host cells to cause infection.

The disease appears as either small or large tumors, at first whitish due to a covering membrane, but later dark and then black from the development of the enclosed smut mass (Fig. 7). The period between infection and the formation of mature sori (tumors) varies, according to Heald (12), from seven days to three weeks, depending upon environmental conditions. The organism may pass through several life cycles during a single growing season.

The percentage of plants infected with smut in various dates of plantings is given in Table 10. Smut infection is greatest in plantings made during the latter part of the planting season. The

TABLE 10. PERCENTAGE OF PLANTS WITH SMUT INFECTION

Year	DATE OF PLANTING								
	Feb. 25	Mar. 12	Mar. 28	Apr. 12	Apr. 28	May 15	June 1	June 15	July 3
1934	.0	.0	1.2	4.4	10.4	.6	2.6	2.3	1.2
1935	.5	.0	.3	.0	.0	2.1	1.2	2.0	2.1
1936	.0	.0	.4	3.7	8.1	1.2	3.3	6.4	2.3
1937	.7	.9	1.8	.6	1.1	3.8	5.5	7.7	13.9
Average	.3	.2	.9	2.2	4.9	1.9	3.2	4.6	4.9

spores from the smut tumors on diseased plants of early-planted corn seem to serve as a source from which infection develops in plants of later plantings. This, however, is not in accord with Heald's (12) statement that "early-planted corn generally smuts worse than a late-planted crop . . . . due to its longer growing period."

FIG. 7.—Corn smut: *a*, tumors on leaves and stem, white covering membrane still intact; *b*, older stage on ear, covering membrane broken and black spores exposed.

The percentage of ears infected with smut in different dates of planting is given in Table 11. A slightly higher percentage was infected in the February planting than in the March plantings, but this probably was without significance. After March 12, the percentage of ears with smut increased with each delay of 15 days in planting. The infection increased from an average of 0.3 per cent in the March 12 planting to 5.8 per cent in the planting made July 3.

TABLE 11. PERCENTAGE OF EARS INFECTED WITH SMUT

Year	DATE OF PLANTING								
	Feb. 25	Mar. 12	Mar. 28	Apr. 12	Apr. 28	May 15	June 1	June 15	July 3
1933	..	..	..	.0	.0	.0	.2	.8	5.0
1934	2.9	.8	.9	2.4	1.9	1.6	.7	1.0	4.4
1935	.0	.0	.0	.4	.0	.7	1.0	2.5	2.3
1936	.2	.0	.7	1.3	1.6	2.1	4.9	9.0	15.3
1937	.3	.2	.0	.0	1.5	2.4	3.9	3.9	1.8
Average	.9	.3	.4	.8	1.0	1.4	2.9	4.8	5.8

The smut disease of corn is not of much economic importance except on corn planted after June 1. Control measures advocated are early planting, not planting corn on the same land oftener than once in three years, and the collection and destruction of smutted ears and stalks before the spores begin to disseminate. The first two measures mentioned are of practical value, but the last may be questioned.

CORN RUST

Rust is caused by the fungus *Puccinia sorghi* Schw. It is found in all of the corn-growing regions of the United States and attacks all types of corn, including flint, dent, pop, and sweet varieties. The disease is most destructive in regions of high humidity, as in the South Atlantic and Gulf states (13).

The spores of the rust organism survive the winter in plant refuse and in the soil. They are disseminated the following spring and summer by the wind and lodge on the plant, where they germinate and the fungus enters the host tissue either through the stomata or other openings.

Rust appears on the leaf as yellowish pustules which change in color to reddish-brown with the development of the masses of spores. The disease may attack the plants in all stages of development, with maximum infection usually developing shortly before maturity is reached.

According to Heald (12), rust injury is due primarily to disturbances in the nutrition of the host: first, to the appropriation of food by the rust pathogene directly from the host cells in which it is living, and, second, to the increased loss of water, due to the rupture of the epidermis by the rust sori.

Early and midseason plantings in south Louisiana are not severely injured by rust. Pustules were found on practically every plant at some stage of its development in each of nine different dates of planting, but the disease spread and caused severe injury only to the June and July plantings. The leaves of the June and July plantings were usually practically covered with pustules, and the leaves had a tendency to dry and die prematurely. No doubt the disease was largely responsible for the lower yields of late plantings (Table 12).

The rust pustules present on the plants of early and midseason plantings seemed to be largely smothered out during June, due probably to hot, dry weather, which is unfavorable to the germination of spores necessary for the development of new infection. The frequent July showers that occur in the vicinity of Baton Rouge seem to be very favorable to the development of corn rust.

FIG. 8.—Rust pustules on corn leaf.

In this locality the rust disease is the main cause of the comparatively low yields and poor quality of grain of late corn. Early planting is probably the only control measure of practical value.

GRAIN YIELDS FROM DIFFERENT DATES OF PLANTING

A summary of the corn grain yields per acre from the different dates of planting used in the experiment for a five-year period is shown in Table 12. This shows that the yields from the March 28 planting were, on the average, slightly better than those from any other dates, and they were slightly better than those from other dates every year except in 1934. In that year the corn was damaged badly by a tropical storm on June 16. The corn on the plots planted early was large enough to be damaged more than that on the later plots. The earlier corn failed to recover fully from the storm injury and gave lower final yields in consequence. Although March 28 is ahead in average yield, the difference between the yield from that date and the yields for the other five dates up to and including May 15 was not great, the average difference between the lowest and the highest being only 6.1 bushels per acre. This was apparently too small a difference to be significant, and from this we may infer that, insofar as yields are concerned, it does not make very much difference what planting date is used provided the planting is done by May 15. Plantings made on dates after May produced successively lower yields and lower quality of grain.

TABLE 12. GRAIN YIELDS FROM DIFFERENT DATES OF PLANTING
(DATA GIVEN IN BUSHELS PER ACRE)

Year	DATE OF PLANTING								
	Feb. 25	Mar. 12	Mar. 28	Apr. 12	Apr. 28	May 15	June 1	June 15	July 3
1933	47.8	47.6	53.6	45.9	43.9	46.7	34.9	29.4	16.6
1934*	20.9	19.8	20.7	23.8	31.8	30.5	31.1	18.8	13.3
1935	60.3	58.8	61.5	54.9	45.7	42.7	35.4	23.9	9.2
1936	56.2	55.3	59.1	46.1†	56.2	58.2	44.3	20.2	7.3
1937	58.0	57.0	59.7	58.3	52.5	45.7	26.7	10.9	3.4
Average	48.6	47.7	50.9	45.8	46.0	44.8	34.5	20.2	10.0

*The low yields in 1934 are attributed to the tropical storm of June 16.
†A high percentage of re-plant plants caused the lower yield of the April 12 planting in 1936.

HEIGHT OF PLANTS AT MATURITY IN RELATION TO DATE OF PLANTING

In 1937 the height of plants at maturity was determined for the different dates of planting. It was found that the February 25 plants were lowest with an average height of 108 inches, and March 12 was next with a height of 115 inches. The March 28 plants

were 124 inches tall, which represented about maximum growth. The plants from the next five plantings had practically the same height as the March 28 plants, but the last planting, on July 3, had slightly lower plants, the height being 118 inches.

TIME OF TASSELING IN RELATION TO THE DATE OF PLANTING

In 1937 a record was kept of the number of days between date of seeding and time of tasseling. This gave a fairly accurate measure of the rate of plant development following the various dates of planting, and it was surprising how much difference there really was. The February 25 date required 94 days for the plants to come into tassel, while the July 3 planting, which made the most rapid development, required but 49 days, barely more than half the length of time. Starting with the first planting date, there was a very regular decrease in the length of time required for development for the successive dates. When plotted, this makes a very symmetrical curve. The curve was still falling when the ninth, or last, date was reached, but the rate of fall was slow, indicating that the limit of rapidity in development had about been reached.

The later planted plants have more heat and a more steady temperature; consequently, if soil and moisture conditions are favorable, they will make more rapid growth and come into maturity in less time. There is also, of course, considerable difference in varieties in respect to the time required for development. The variety used in this experiment, Yellow Creole, was a medium late variety. Tests have shown that the later varieties, although requiring more time for maturity, make better yields in Louisiana than early varieties.

GENERAL DISCUSSION

In south Louisiana the planting dates for corn vary considerably in different localities. It is the practice in many places to divide the planting, putting in some early and some late. This may serve to use the farm labor more efficiently, better utilize crop land, and also, may serve as a partial insurance against adverse weather conditions.

The date of planting in some localities also varies in different years, depending upon the immediate weather conditions and relative urgency of a particular type of work. This variation usually does not exceed 10 days or two weeks. In particular localities, however, where early planting is not the common practice, the need for early feed may necessitate a variation of a month or six weeks.

This study shows that in south Louisiana there is a comparatively wide range of planting dates within which corn may be planted with an equal or nearly equal chance for a crop. There

was no significant difference in yields from the six planting dates ranging from February 25 to May 15. With this leeway available, the corn grower can choose a date that will dodge the peak of certain insect infestations and also fit in with the economy of his farm operations.

This study further shows that the majority of these insect pests and fungous diseases—corn ear worm, cane borer, smut, rust, and Diplodia ear rot—are worst on late planted corn. This argues strongly in favor of early planting. The grain weevil was worse in the earlier planted plots in this experiment, but that damage could have been lessened materially had the corn on those plots been gathered as soon as it was ripe. The southern corn root worm was also worse on the earliest planted corn. It can be avoided largely by planting during April. This is early enough to make about maximum yields and late enough to miss the maximum root worm infestation. The Physoderma disease is worse on the early corn than it is on late, but it is not one of the more serious diseases, and if crop rotations are used, will cause but very little trouble.

SUMMARY

During the years of 1933 to 1937, inclusive, an experiment was conducted on Mississippi alluvial soil at Baton Rouge to determine the effect of the date of planting on corn yields, infestation of certain insects, and diseases.

Nine plantings were made each year at approximately 15-day intervals. These covered the period from February 25 to July 3. The cultural practices were the same for all plantings.

With the exception of 1933, data were taken each year on the yield and on the infestation of the southern corn root worm, corn ear worm, cane borer, weevil, Physoderma, smut, Diplodia dry rot, and rust. Only yields were obtained in 1933.

The difference in yield was probably not significant in plantings made from February 25 to May 15. Plantings made in June and July consistently produced lower yields.

Excepting the July 3 planting, the rapidity of growth and development was greater in the later plantings.

A high infestation of southern corn root worms occurred only in the February and March plantings.

The corn ear worm was found to be less plentiful in the March and April 12 plantings and the ears were apparently injured to a less extent.

The number of plants infested with the cane borer was approximately the same in the February, March, and April 12 plantings, and increased in each planting made thereafter, the infestation for the later plantings being approximately 100 per cent.

With each delay of 15 days in planting from February 25 to July 3, the percentage of ears infested with cane borers increased 4.24 per cent, the range being from 10.9 to 44.8 per cent.

A higher percentage of ears infested with weevils and more weevils per infested ear were found in the earliest and latest plantings.

Physoderma, or brown spot, disease was most severe in the May 15 planting, but the difference was small in the earlier plantings. The June and July plantings were but slightly affected.

The February and March plantings were found to be least infected with Diplodia dry rot.

Smut infection was lowest in early spring plantings.

The rust disease caused serious injury to the June 15 and July 3 plantings each year, and during some years to the June 1 plantings.

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